
# EUV into production with the NXE – platform

October 2010

# EUV process viability confirmed by two 0.25 NA Systems

imec

COLLEGE OF NANOSCALE SCIENCE & ENGINEERING
UNIVERSITY AT ALBANY State University of New York

| | |
|---|---|
| λ | 13.5 nm |
| NA | 0.25 |
| Field size | 26 x 33 mm² |
| Magnification | 4x reduction |
| Sigma | 0.5 |

- 300mm Single stage
- linked to track
- Single reticle load
- Uses TWINSCAN technology
- Sn discharge source

SONY intel Micron
hynix
GLOBALFOUNDRIES
Panasonic
SAMSUNG
SEMATECH
ELPIDA
TOSHIBA
PSC
tsmc
Oct IBM
Infineon
ASML

# ASML EUV product roadmap

## Source roadmap in place for cost effective production

| | 2006<br>Proto System | 2010<br>NXE:3100 | 2012<br>NXE:3300B | 2013<br>NXE:3300C |
|---|---|---|---|---|
| **Qualification CD** | 32 nm | 27 nm | 18 nm | 16* nm |
| **NA / σ** | 0.25 / 0.5 | 0.25 / 0.8 | 0.32 / 0.2-0.9 | 0.32 / OAI |
| **Overlay (SMO)** | < 7 nm | < 4.5 nm | < 3.5 nm | < 3 nm |
| **Throughput** | 4 W/hr | 60 W/hr | 125 W/hr | 150 W/hr |
| **Dose, Source** | 5 mJ/cm$^2$, ~8 W | 10 mJ/cm$^2$, >100 W | 15 mJ/cm$^2$, >250 W | 15 mJ/cm$^2$, >350 W |

**Main improvements**
**1)** New EUV platform: NXE
**2)** Improved low flare optics
**3)** New high sigma illuminator
**4)** New high power source
**5)** Dual stages

**Main improvements**
**1)** New high NA 6 mirror lens
**2)** New high efficiency illuminator
**3)** Off-axis illumination optional
**4)** Source power increase
**5)** Reduced footprint

**Platform enhancements**
**1)** Off-Axis illumination
**2)** Source power increase

* Requires <7 nm resist diffusion length





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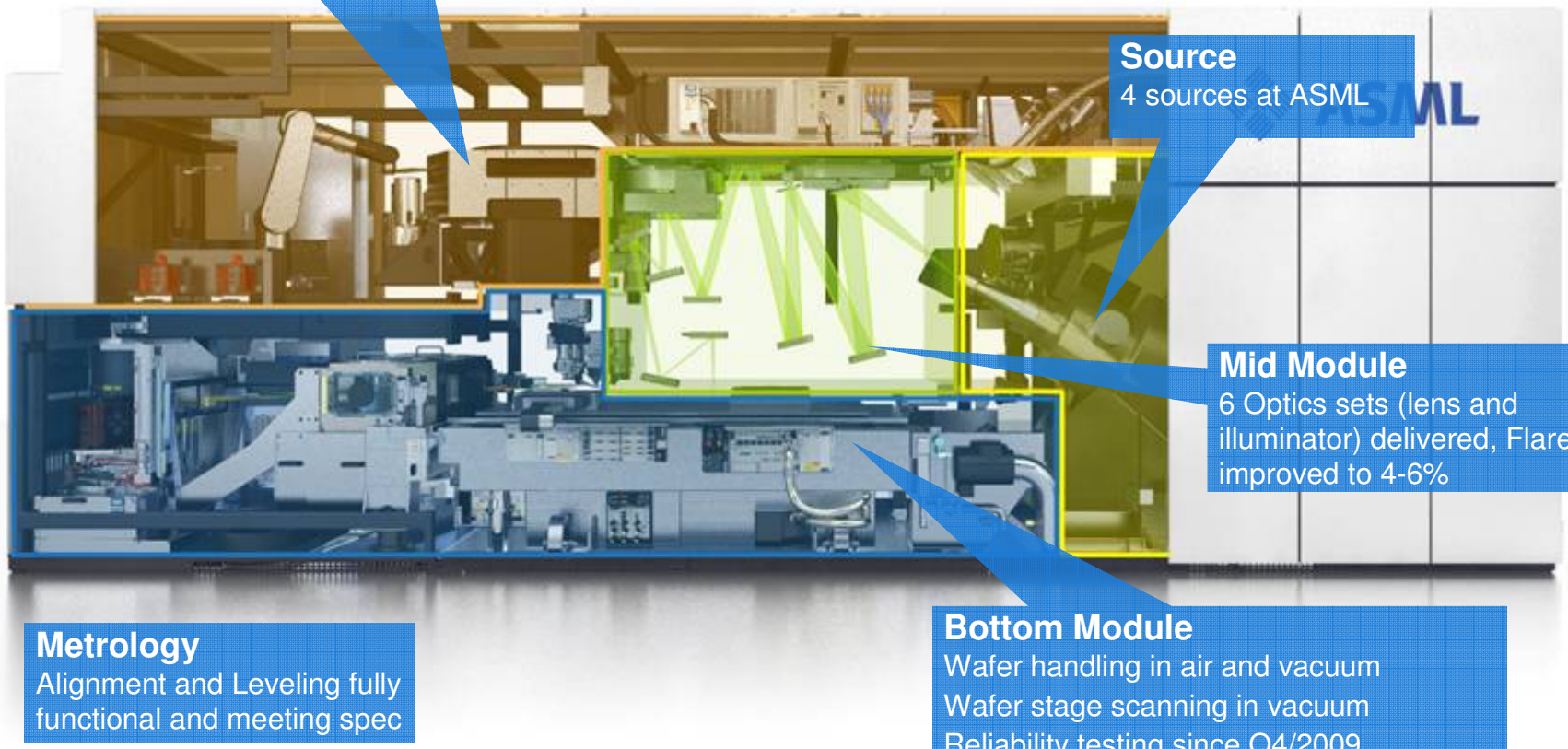
# NXE:3100 integration status, October 2010

**Top Module**
Reticle Handling in air and vacuum
Stage control in vacuum
5 top modules installed
Reliability testing since Q4/2009

**Vacuum system** design verified, <1hour pump down as designed



**Source**
4 sources at ASML

**Mid Module**
6 Optics sets (lens and illuminator) delivered, Flare improved to 4-6%

**Metrology**
Alignment and Leveling fully functional and meeting spec

**Bottom Module**
Wafer handling in air and vacuum
Wafer stage scanning in vacuum
Reliability testing since Q4/2009
All 6 bottom modules integrated





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# 5 NXE:3100 systems are completed

## First system shipping to a customer

NXE:3100 #1

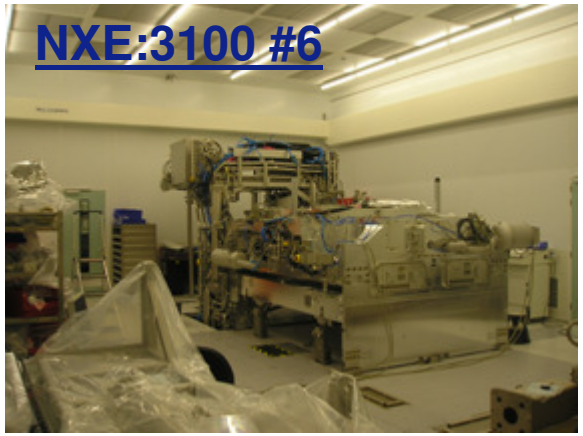
NXE:3100 #2

NXE:3100 #3

NXE:3100 #4

NXE:3100 #5


NXE:3100 #6







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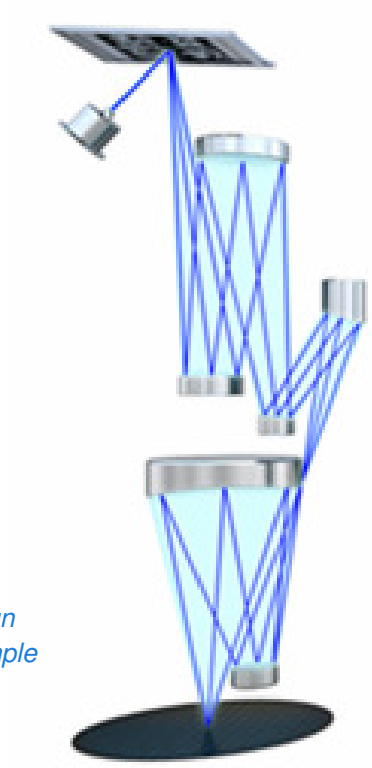
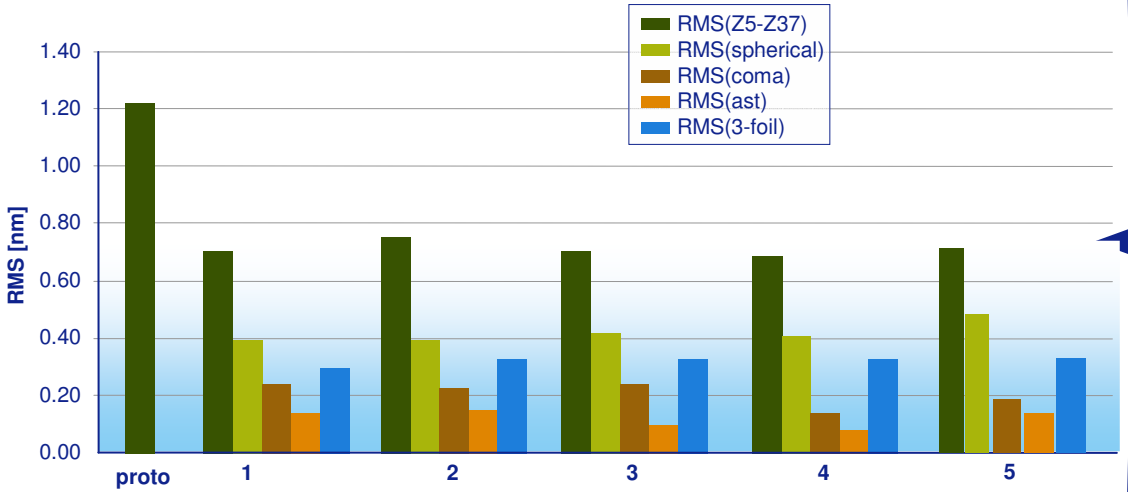
# NXE:3100 lenses are manufactured and qualified

## Wave front qualified by EUV – interferometer

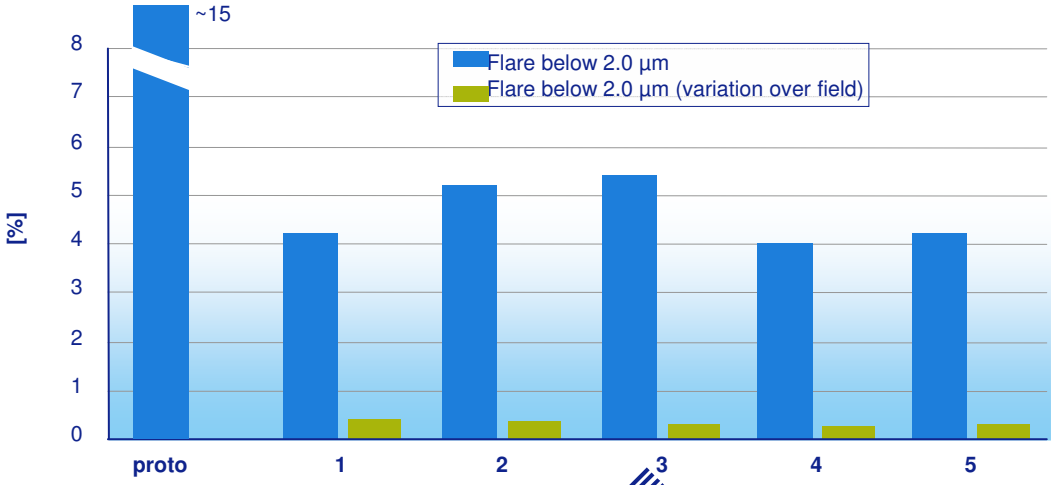


*design example*

- Field size: 26mm
- Chief ray at mask: 6°
- 4x reduction ring field design
- Design is extendable to higher NA




**NXE:3100 lenses within flare specifications**





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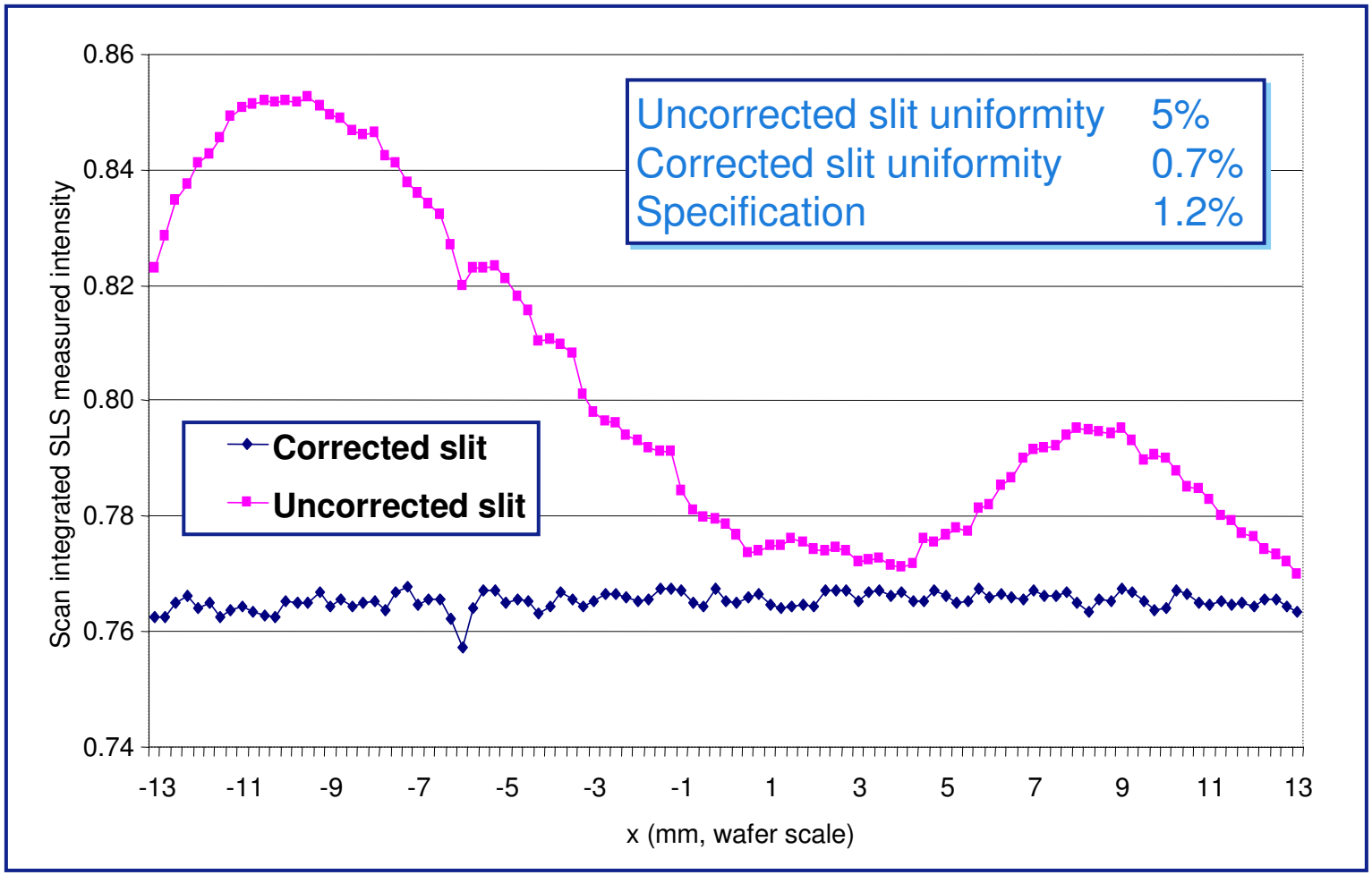
# NXE:3100 slit uniformity capability well within specification





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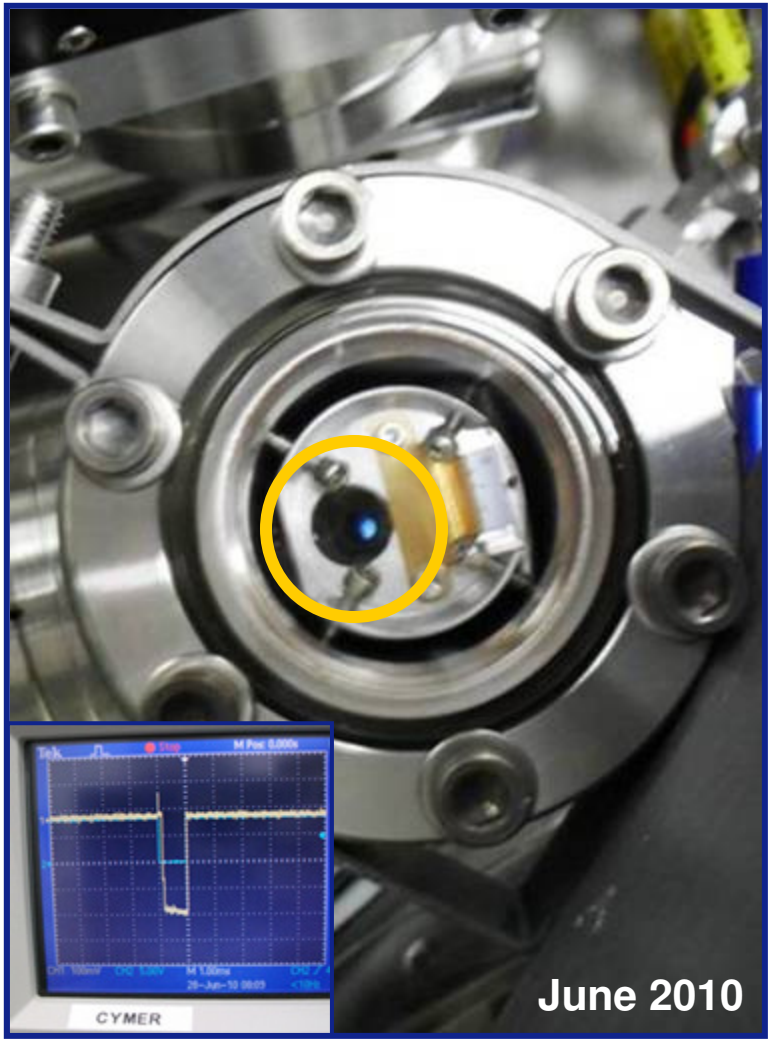
# Source

# First NXE:3100 exposure was done July 2010









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# Source performance roadmap

- ASML has received three LPP sources and one DPP source
  - Power will be upgraded in two steps

| | | LPP | | DPP | |
|---|---|---|---|---|---|
| **Timing** | **Source Config** | **Expose Power** | **Throughput** | **Expose Power** | **Throughput** |
| Q3/2010 | Integration | 1W | <1wph* | 3W | 2wph** |
| Q4/2010 | Integration | 7W | 4wph | 15W | 10wph |
| Q1/2011 | Upgrade 1 | 40W | 25wph | 65W | 35wph |
| Mid 2011 | Upgrade 2 | 100W | 60wph | 100W | 60wph |

* integrated with NXE:3100
** predicted





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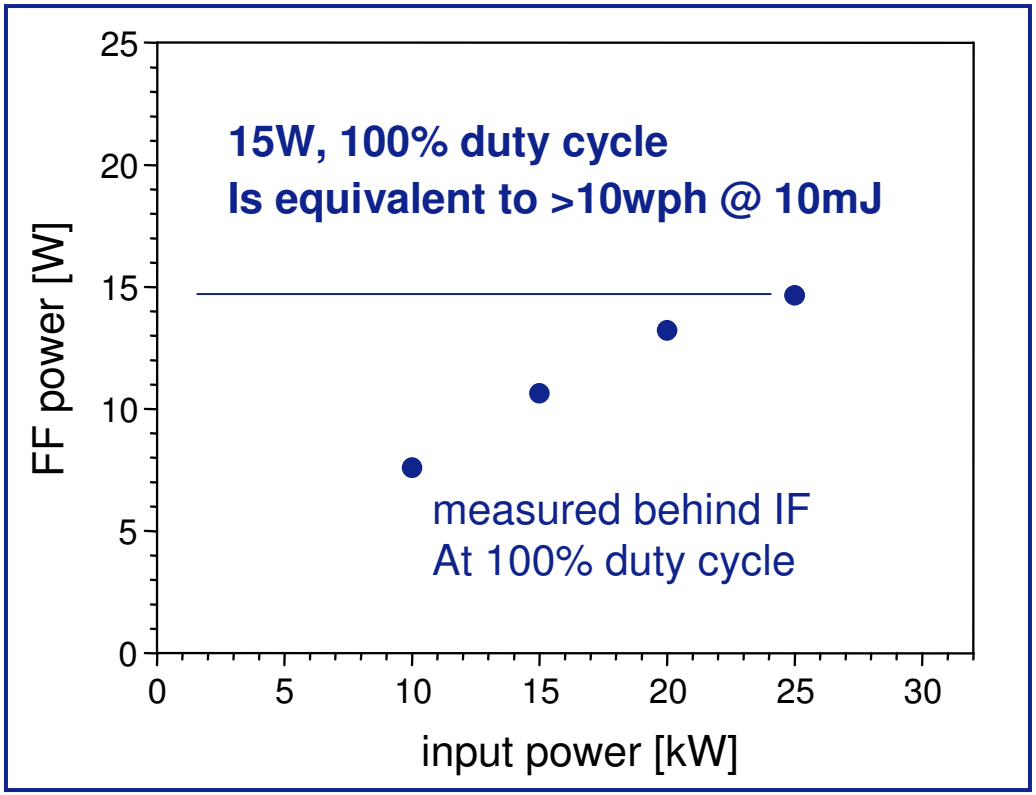
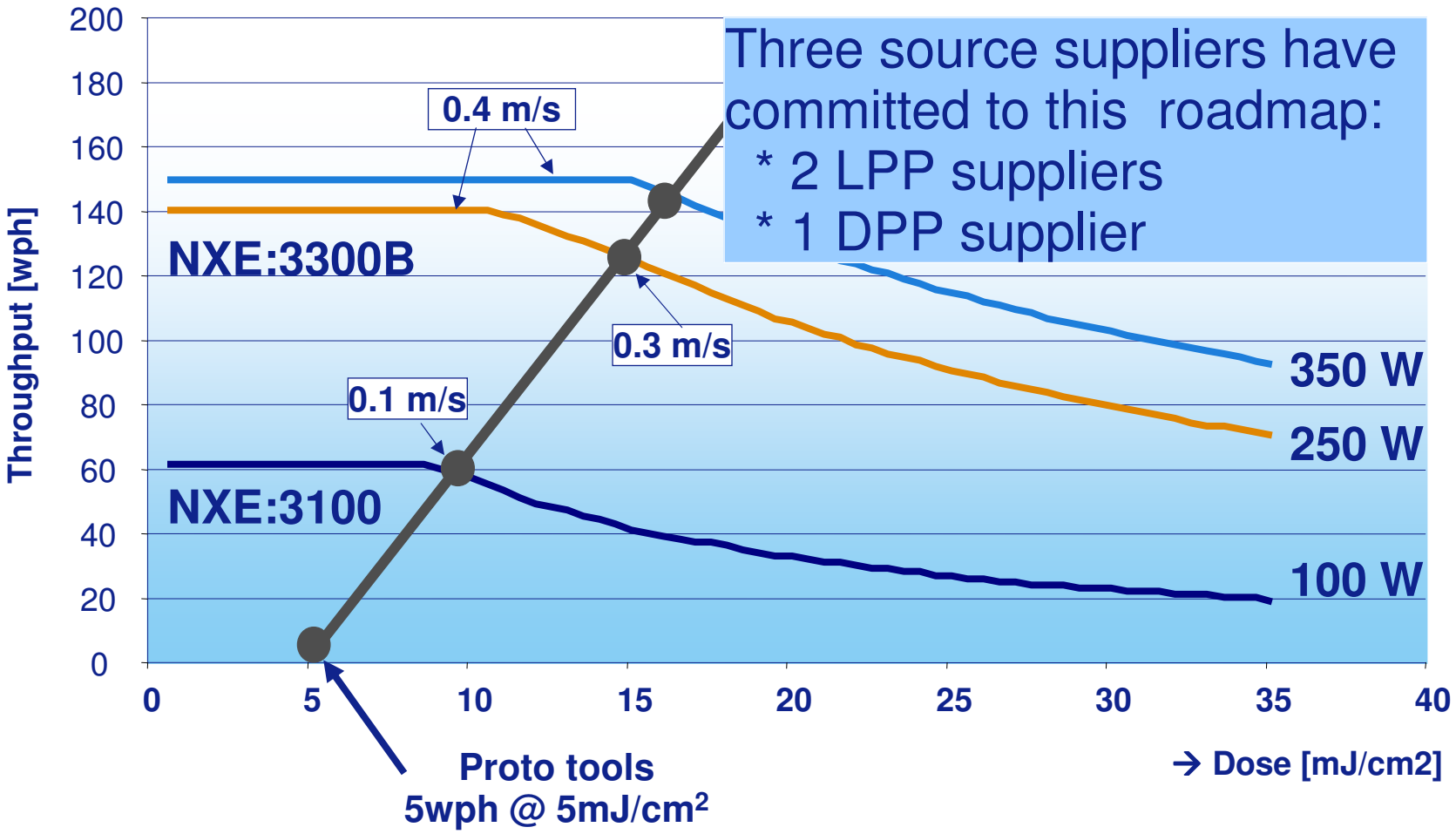
# DPP 14.7W continuous exposure power

- Stand - Alone 14.7W continuous power proven at 25 kW input power
  - 0.2% dose control proven



# Stage speed, optics transmission, source power, and resist sensitivity all have to improve to meet required cost targets





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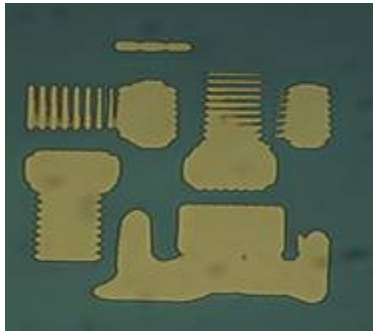
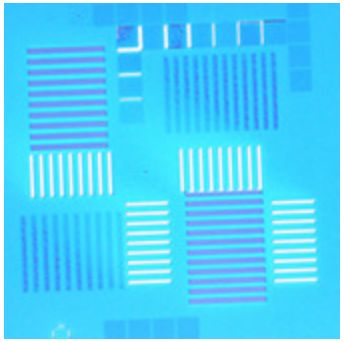
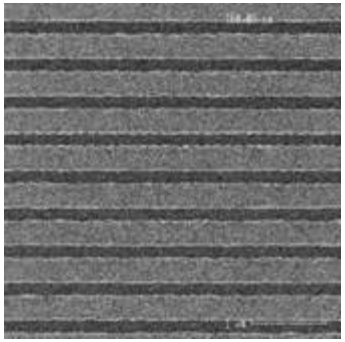
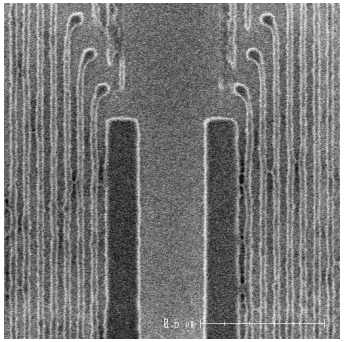
# NXE:3100 Performance

Public, EUV symposium Kobe

# NXE:3100 imaging progress

| July 2010 | August 2010 | September 2010 | September - End |
|---|---|---|---|
|  |  |  |  |
| • First lines visible<br>• No setup done<br>• Static exposure | • 1.3um lines<br>• Limited setup<br>• Static exposure<br>• Limited by focus | • 250nm lines, 500nm pitch<br>• Scanning exposure<br>• Coarse focus setup<br>• Limited by reticle stage tilt | • 27nm hp<br>• Scanned exposures<br>• Coarse setup |





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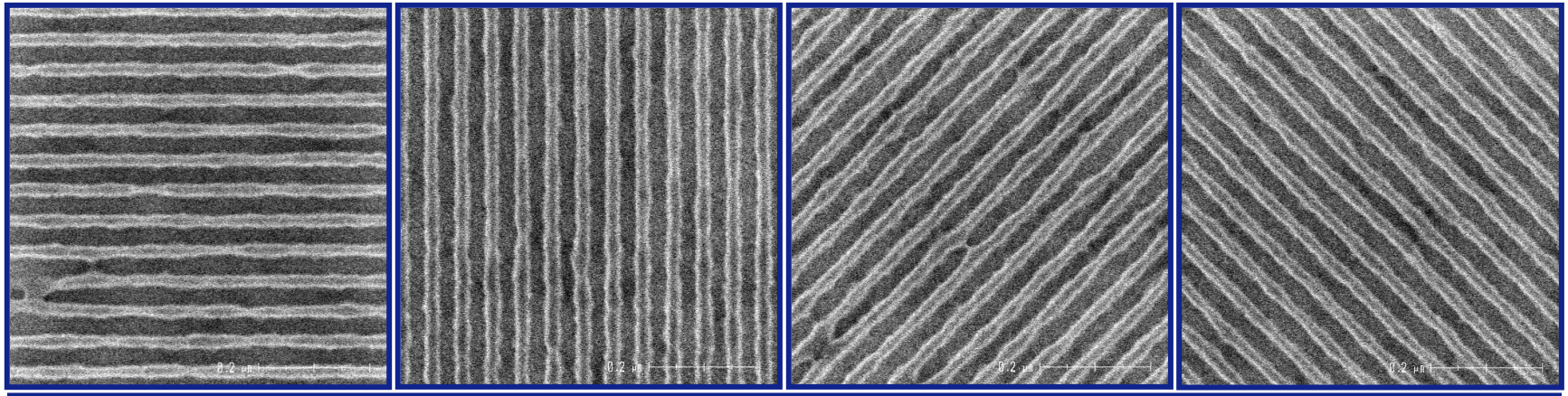
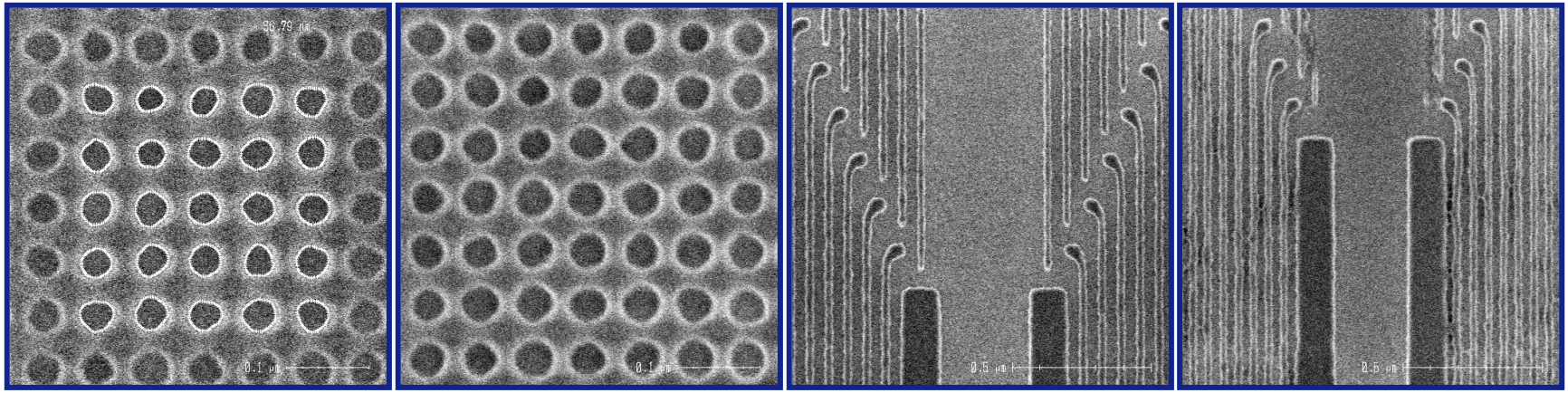
# NXE:3100 27nm imaging September 2010



27p54nm L/S



32p64nm contact holes | 34p68nm Flash | 27p54nm Flash





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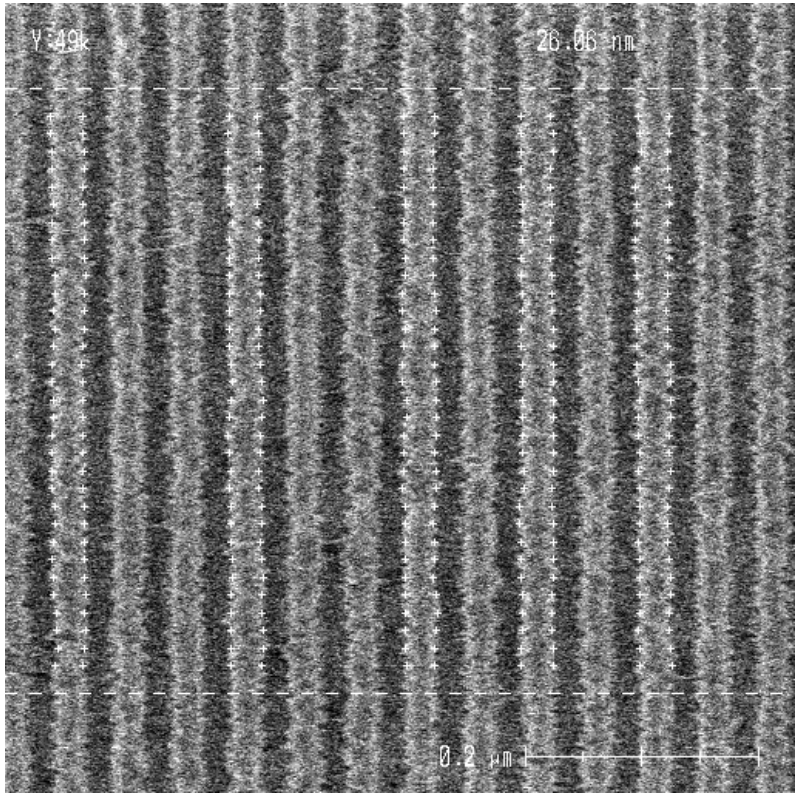
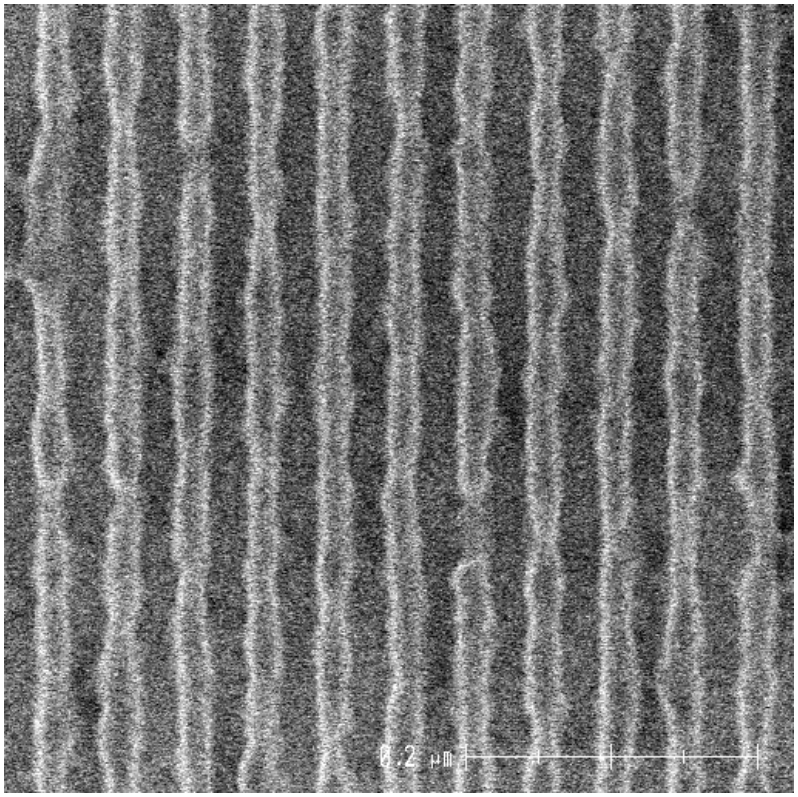
# NXE:3100 – smaller and smaller Oct. 15, 2010

## 25nm HP




Please note asymmetric magnification SEM

## 24nm HP




Off-line processing



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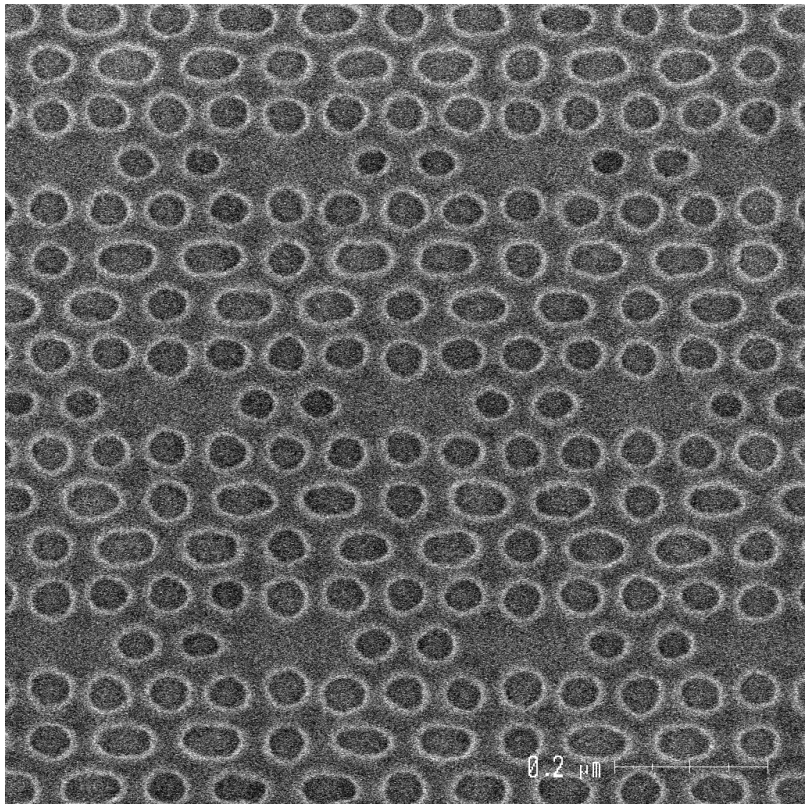
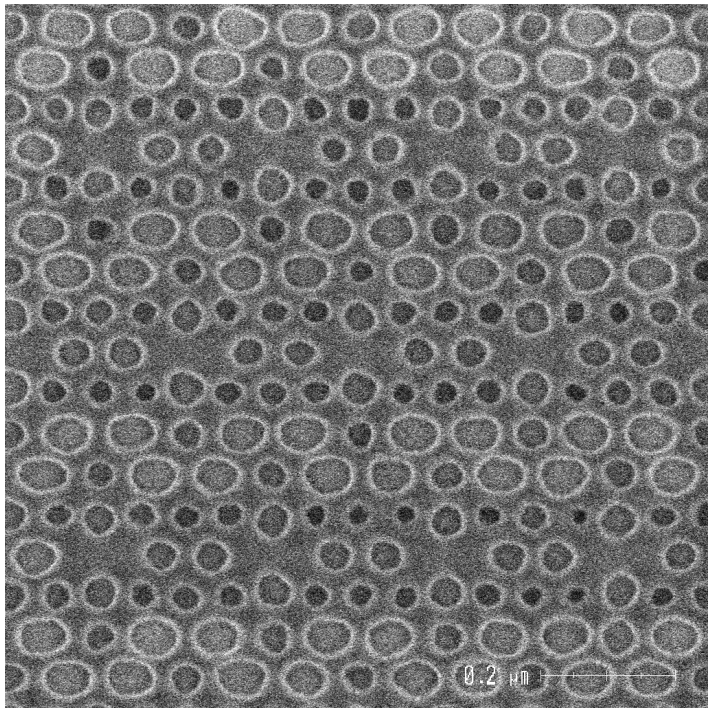
# NXE:3100 16nm node SRAM contacts exposed




October 9 Cell-size = 0.048µm$^2$




October 15 Cell-size = 0.038µm$^2$





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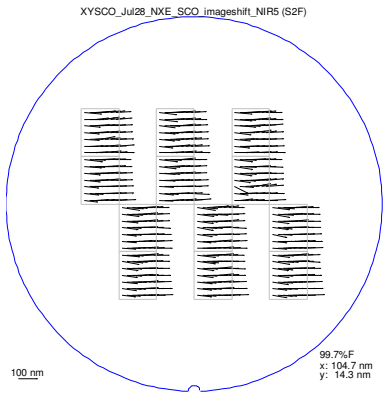
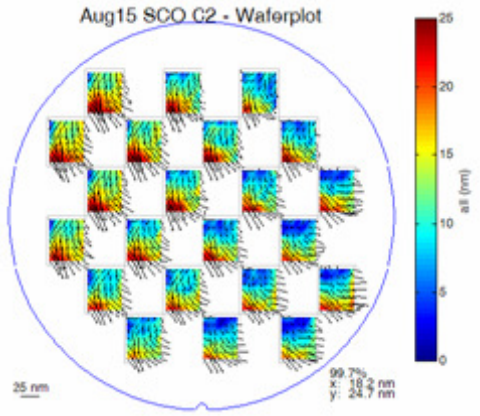
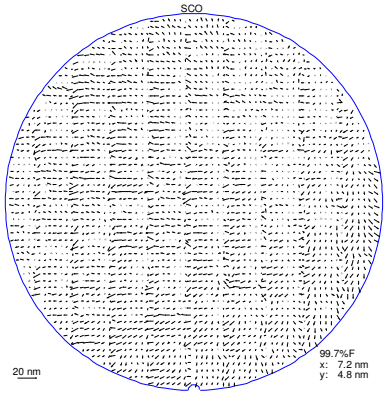
# NXE:3100 overlay integration progress

- To mitigate source availability, overlay integration was started on an NXE:3100 with an ArF laser
  - This has allowed us to make substantial progress

| July 2010<br>Raw SCO (105,14) | August 2010<br>Raw SCO (18,25) | September 2010<br>SCO (7.2, 4.8) |
|---|---|---|
|  |  |  |





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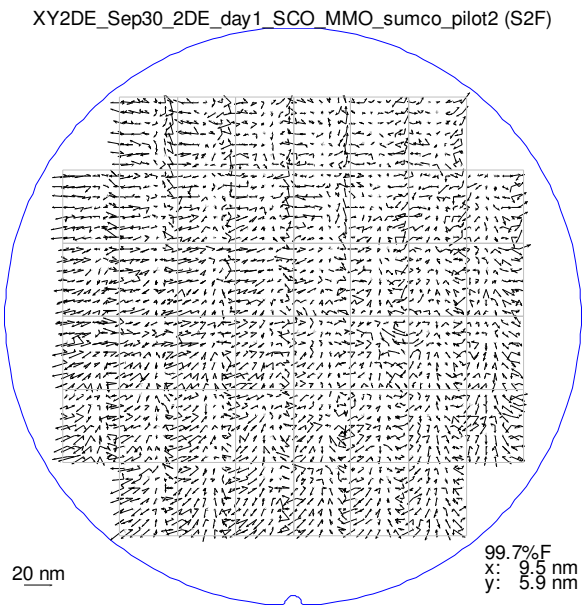
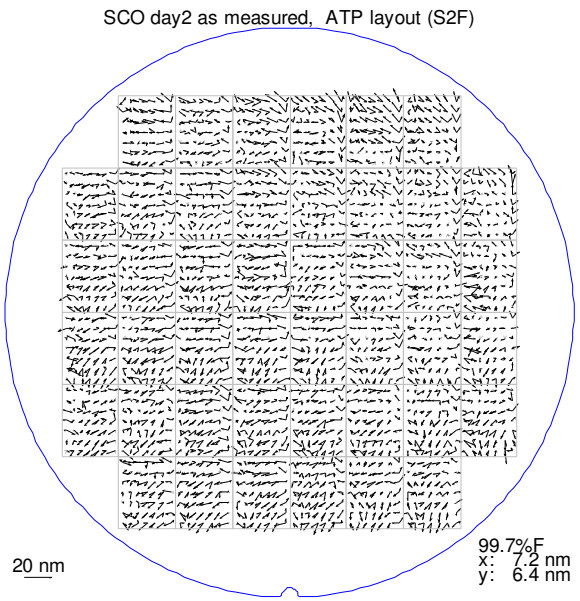
# Multi-day overlay stability demonstrated

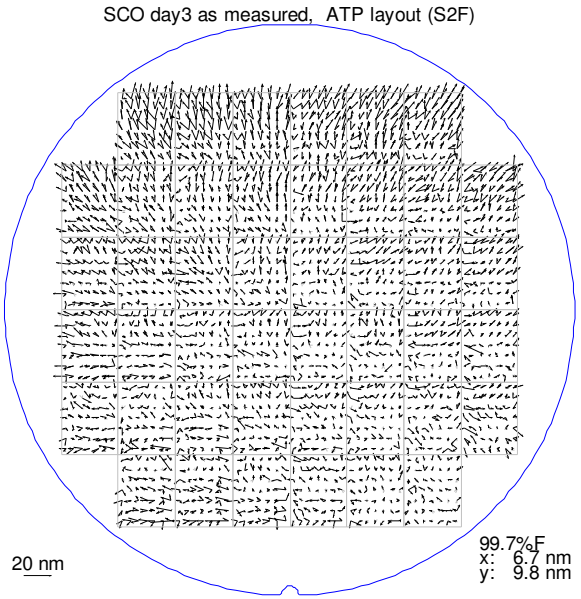
- 3 day single chuck overlay on NXE:3100
  - Stability shown, performance improvement ongoing




(9.5,5.9)




(7.2,6.4)




(6.7,9.8)





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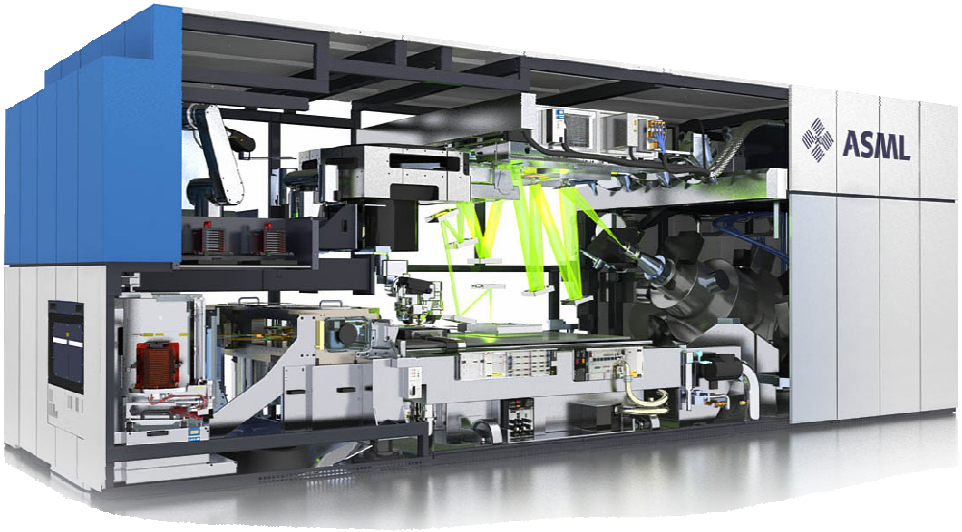
# NXE:3300B

Public, EUV symposium Kobe

# The NXE:3300B is the second product build upon the NXE-platform H1 2012

- Higher 0.32 NA optics and reduced foot-print for
  - improved resolution of 18 nm with off axis illumination
  - Improved OV in line with device requirements
  - improved cost-of-operation:
    - higher productivity at higher dose
    - off-axis illumination without energy loss




| System performance | NXE:3300B |
|---|---|
| NA | 0.32 |
| Resolution (half-pitch) | 22 nm (18 nm with OAI) |
| Overlay (SMO / MMO) | < 3.5 / 5.0 nm |
| Throughput | 125 wph @ 15 mJ/cm$^2$ |





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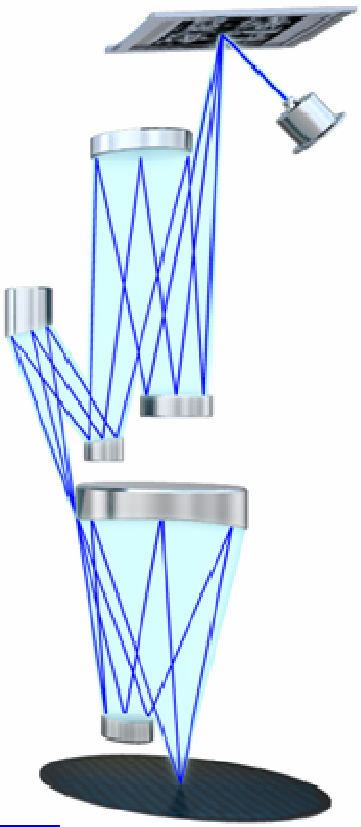
# Six-mirror lens design is extendable to 0.32 NA

*Resolution improves from 27 to 18 nm with Off – Axis Illumination*

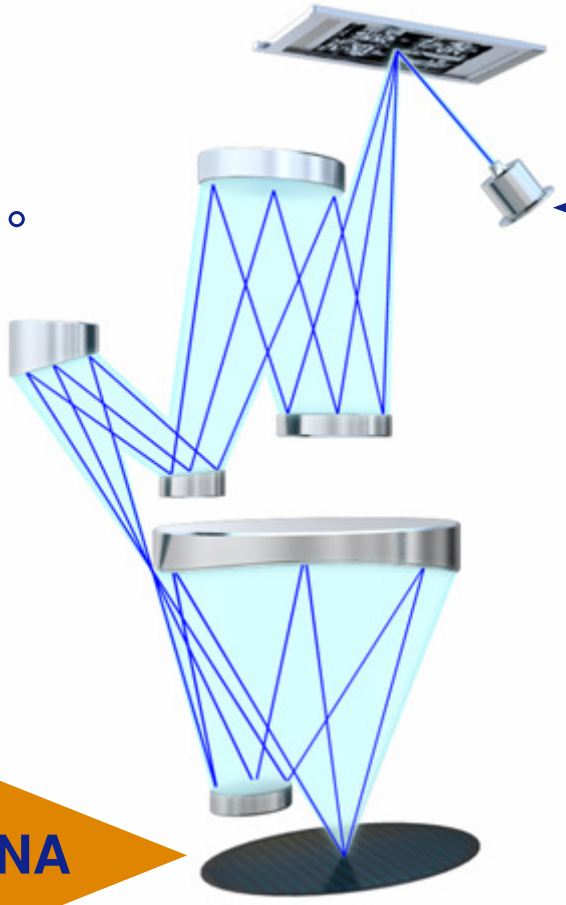


Field size remains 26 mm

Chief ray at mask remains 6°

- Main technical changes:
  - Larger mirrors
  - Steeper aspheric mirrors
  - High angles of incidence

**0.25 NA** → **0.32 NA**



design examples

# NXE:3300 cost footprint target is <50% of NXE:3100

## Incl. shared service area, for multiple systems in fab.

Service Area
Sub fab Area

NXE:3300 Footprint



Slide 23 | 

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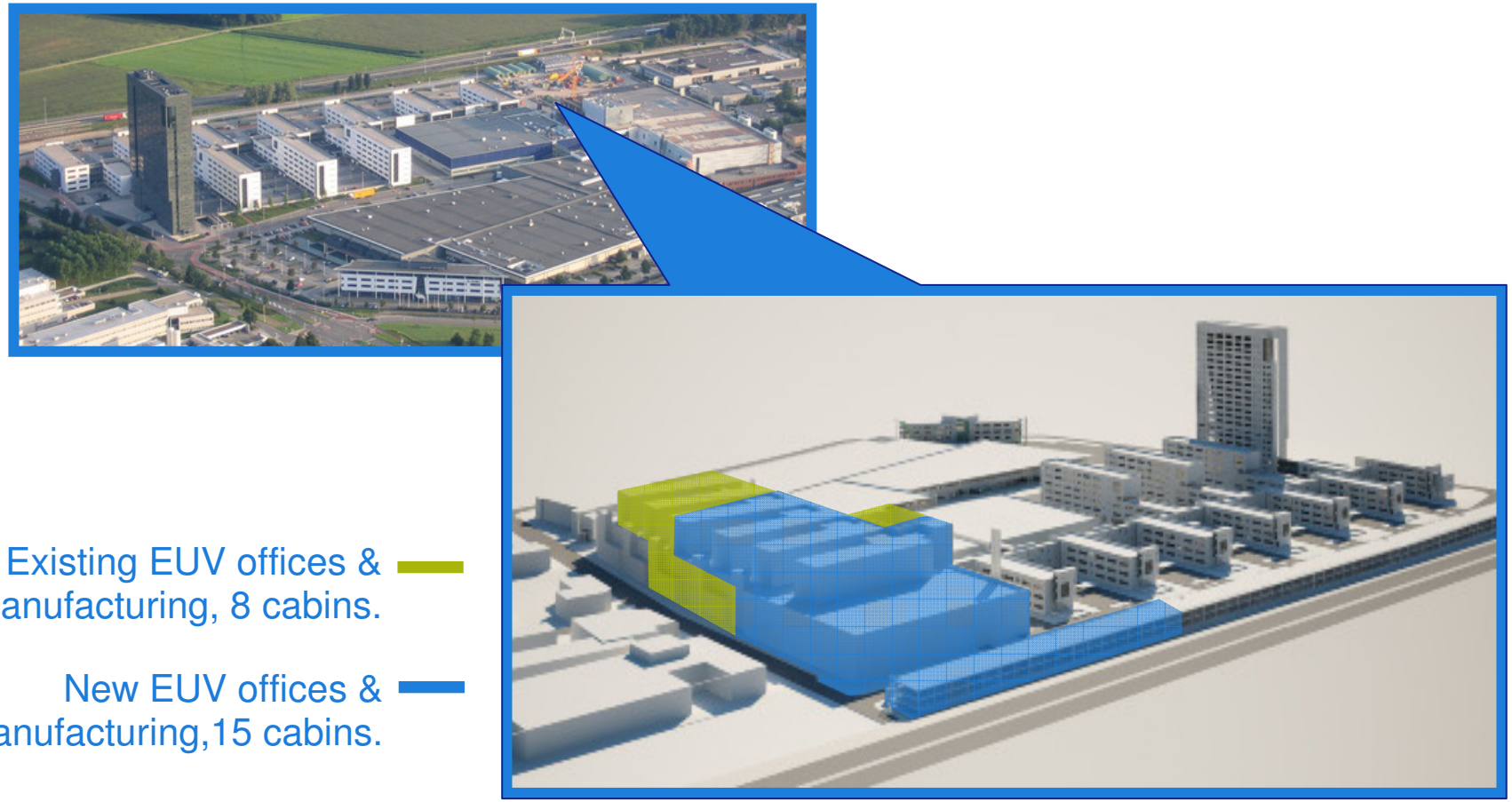
# Construction of new EUV production facilities has started

## NXE – production capacity increases ~3x



Existing EUV offices & manufacturing, 8 cabins.

New EUV offices & manufacturing,15 cabins.





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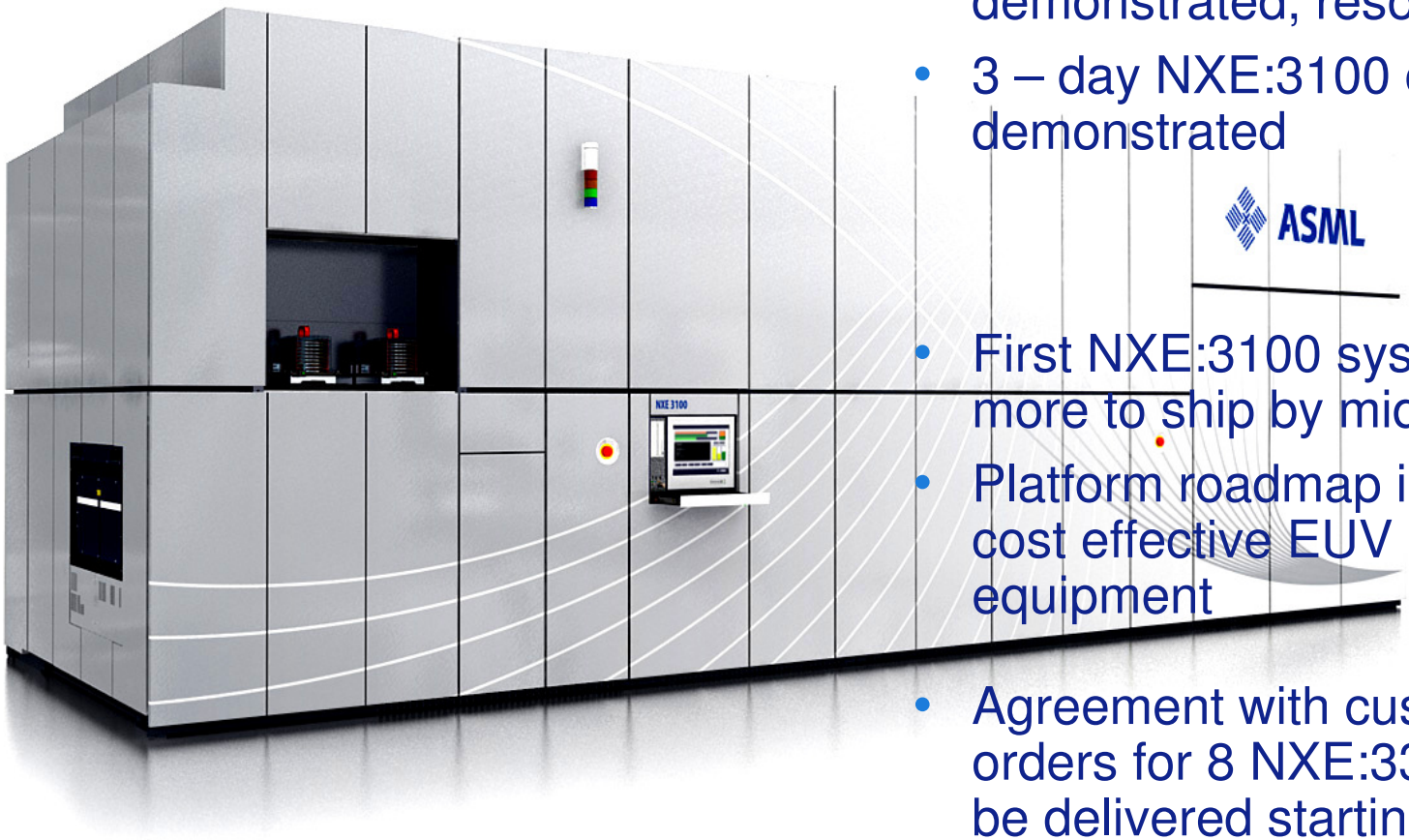
# EUV into Production with the NXE platform




- Full wafer imaging of 27nm L/S demonstrated, resolution 24 nm
- 3 – day NXE:3100 overlay stability demonstrated
- First NXE:3100 system shipping, 5 more to ship by mid 2011
- Platform roadmap in place to offer cost effective EUV production equipment
- Agreement with customer on orders for 8 NXE:3300 systems to be delivered starting 2012

# Acknowledgement

ASML and partners are grateful to the Dutch, German and French governments for their financial contributions and to the MEDEA+ and CATRENE association

**MEDEA+** (Σ!2365) is the industry-driven pan-European program for advanced co-operative R&D in microelectronics to ensure Europe's technological and industrial competitiveness in this sector on a worldwide basis

**CATRENE** (Σ! 4140), Cluster for Application and Technology Research in Europe on NanoElectronics, will effect technological leadership for a competitive European ICT industry. **CATRENE** focuses to deliver nano-/microelectronic solutions that respond to the needs of society at large, improving the economic prosperity of Europe and reinforcing the ability of its industry to be at the forefront of the global competition.